Space Weather Technical Forecast

Issued on Monday, 17 July 2023 at 13:28 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Minor/Moderate R1/R2 Blackouts likely throughout G1/ G2 Minor/Moderate likely Storms Day 1 (17 July), and possible Day 2 (18 Jul).

Analysis of Space Weather Activity over past 24 hours
Solar Activity: Moderate, with two M-flares observed, peaking M4.0 at 16/1746 UTC from AR3363 in the southwest quadrant. There are currently nine sunspot regions on the visible disc. AR3363 persists as a large and mature region but a previous delta spot has faded. AR3372 is the other large region on the disc, and the source of the other M-class flare. This is a large open region in the northeast quadrant, with a simple and symmetric leader spot, but a more complex trailer containing a small delta spot. AR3373, also in the northeast, is also a moderately sized region, with mature penumbra having developed amongst its intermediate spots, but growth has recently slowed.

Several CMEs were observed leaving the Sun over the past 24 hours, however none of them are currently considered Earth-directed. The largest and fastest CMEs originated from a region located well beyond the western horizon. Further CMEs from AR3363 have been analysed as not being Earth-directed. A fast CME from the western side of the disc, will be analysed once further imagery becomes available.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by ACE and DSCOVR at L1, showed the arrival of a CME from a yet to be determined source. The solar wind rose sharply from background, near 350 km/s to around 600km/s at 17/0926 UTC. The density also rose from below average to average levels with a peak of 5ppcc. The total magnetic field (IMF), Bt, was initially weak, below 7nT but jumped sharply at 17/1837 UTC to then persist at moderate, 11-15nT, this then slowly eased back to weak values by the end of the period. The north-south component become moderately southward at this time, falling to a minimum of -12nT at 16/2155 UTC with a further persistently moderate negative period between around 17/0500 UTC and 17/1000 UTC. Phi angle was consistently negative (towards the Sun). Geomagnetic activity was Quiet (Kp 0-1) at first, but rose to be Unsettled to Active (Kp 3-4) from 16/1800 UTC. A G1/Minor Storm interval was observed between 17/0600-170900UTC.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, has fitfully declined from 2.4 pfu and has now fallen below the 1 pfu level. High energy electron flux (greater than 2MeV) was at background levels. The 24-hour integrated fluence was below the Active (1e8 integrated pfu) threshold on a decreasing trend. A fluence of 1.35e6 pfu was recorded at 16/0000 UTC.

Four-Day Space Weather Forecast Summary
Solar Activity: Activity is expected to remain Moderate, with occasional M-class flares and a slight chance of X-class flares.

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Solar Wind / Geomagnetic Activity: Current CME influence is expected to gradually ease early on 17 July but may be enhanced by a possible second CME which is due to arrive later on 17 July. CME effects could then continue with a declining magnitude into 18 July. A coronal hole high speed stream could then connect on 18 and 19 July, but this is low confidence due to the weak appearance of the feature. Solar wind conditions are then forecast to decline towards background from later on 19 and into 20 July.

Unsettled to Active geomagnetic activity is likely at first, with a likelihood of G1/Minor storms, perhaps easing for a time later on 17 July before the arrival of the possible second CME later in the day. G1/G2 Minor/Moderate storms are likely due to this second feature. Ongoing CME effects are expected into 18 July, before gradually easing back to mainly Quiet with Unsettled spells by 19 July. However any further enhancement from the coronal hole is likely to bring a spell of Active conditions, most likely on 19 July.

Energetic Particles / Solar Radiation: The high energy (greater than 10MeV) proton flux has a slight chance of reaching the S1/Minor Storm threshold through the period, should any large flares occur. However the probability is low and expected to decrease over the following days. An increase in observed flux may also occur just ahead of the CME arrival expected on 17 July. High energy electron flux (greater than 2MeV) is expected to be at mostly background, perhaps briefly moderate to high later in the period, however fluence is most likely to remain below the Active (1e8 integrated pfu) threshold throughout with only a low risk of reaching the active threshold on 19 or 20 July.

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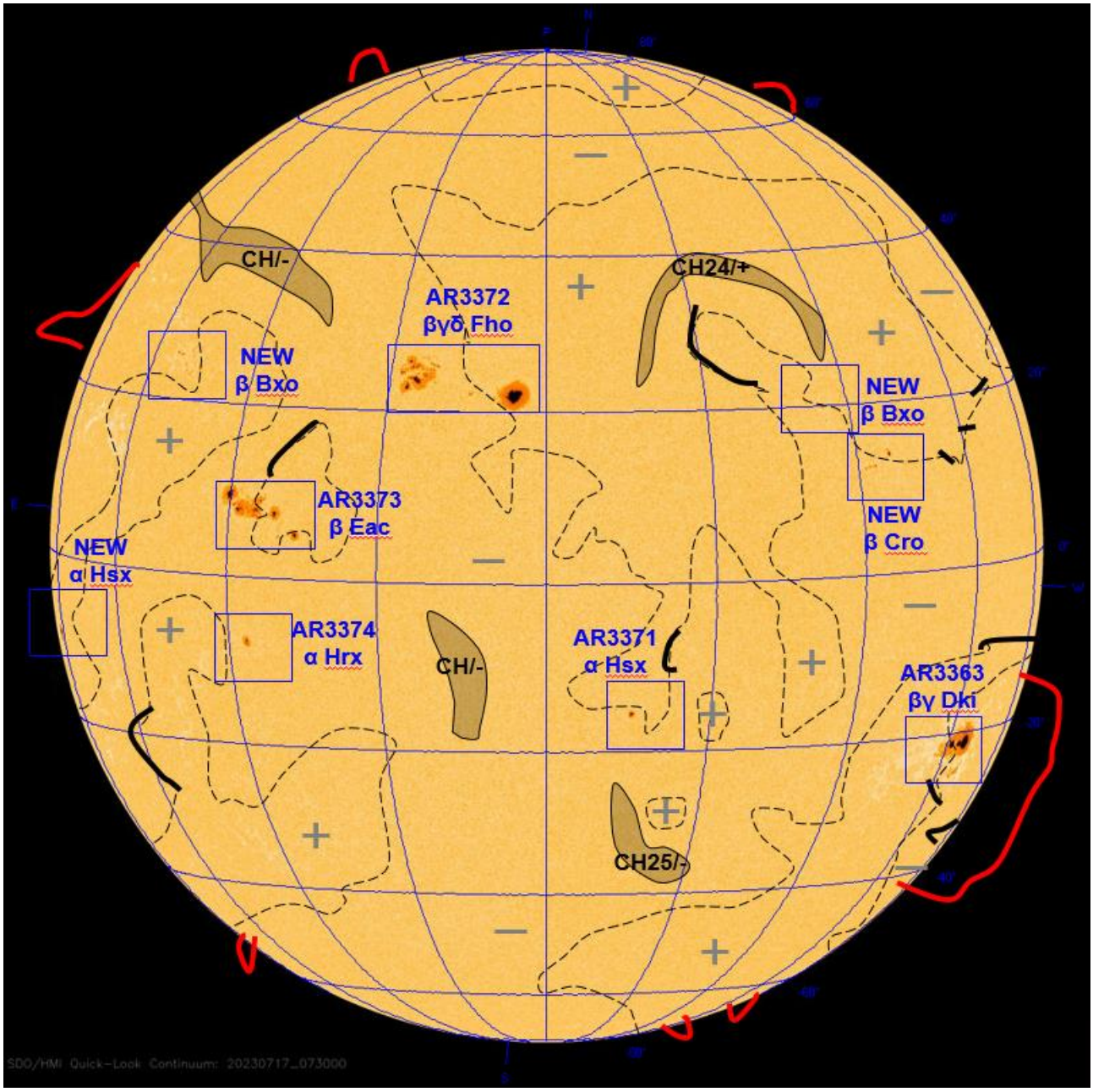
Figure 1. Solar Analysis Valid 17/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There is an ongoing influence from a CME which arrived at Earth late on 16 July, with a likelihood of further G1/Minor Storms. Uncertainty exists around whether this was the CME which left the south centre disc on 14 July, which was due to arrive later on 17 July. The 14 July CME was difficult to analyse with an inherent large margin of error in the forecast arrival time of 17/1400UTC with a range of 10 hours either side. Enlil ensemble output is also a suggesting a large spread of possible arrival times. Based on this analysis, the current CME effects are likely to continue through 17 July with a likelihood of further G1/Minor Storm periods, and a possible enhancement, should a further CME arrive later in the day. These effects would then continue into 18 July before declining.

A coronal hole high speed stream from coronal hole 24 is then possible on 18 or 19 July, although as this is a small feature, limited enhancements are possible, which may be masked by the continuing CME effects.

Geomagnetic activity is therefore expected to be Unsettled through much of 17 July, with Active or G1/G2 Minor or Moderate storms possible overnight into 18 July. Active intervals are then possible on 18 July should the CME effects decline and the coronal hole high speed stream connect favourably with Earth. Declining activity is then expected through 19 and 20 July.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	70	40	5	5
Strong	G3	No	20	10	1	1
Severe	G4	No	2	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
14/2155	Asymmetric full	C8.8 flare of AR3370 and filament eruption	S Centre	832 km/s	17/1400 UTC	Low confidence – may have arrived early.

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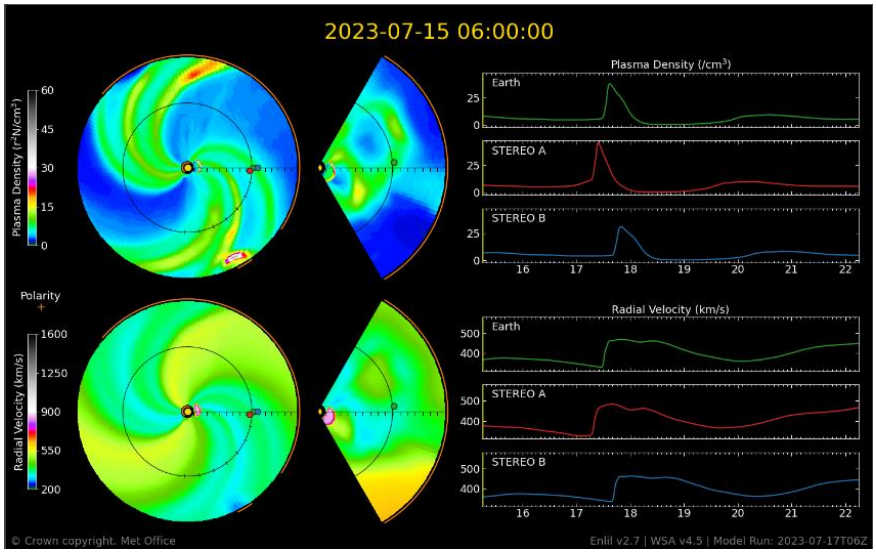
Figure 2: MOSWOC Enlil model showing potential arrival of CME and MOSWOC Enlil ensemble demonstrating the wide range of potential arrival times.



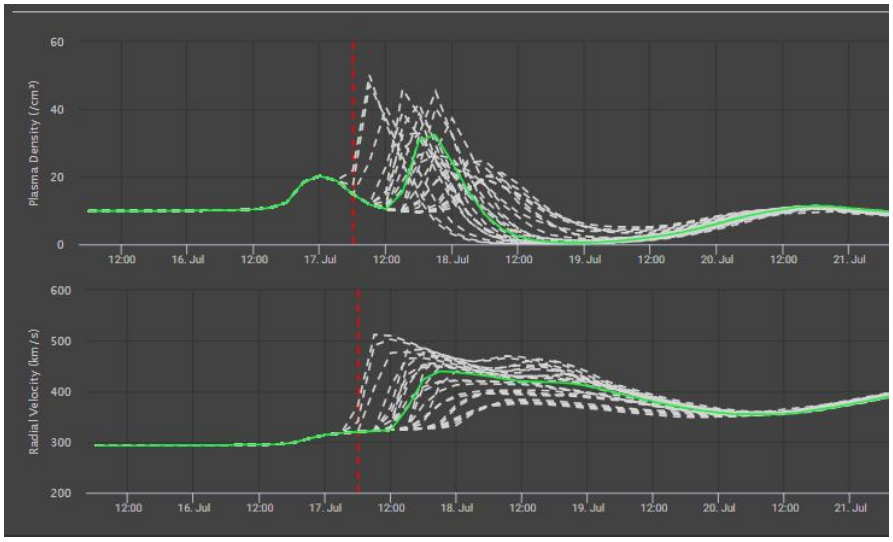


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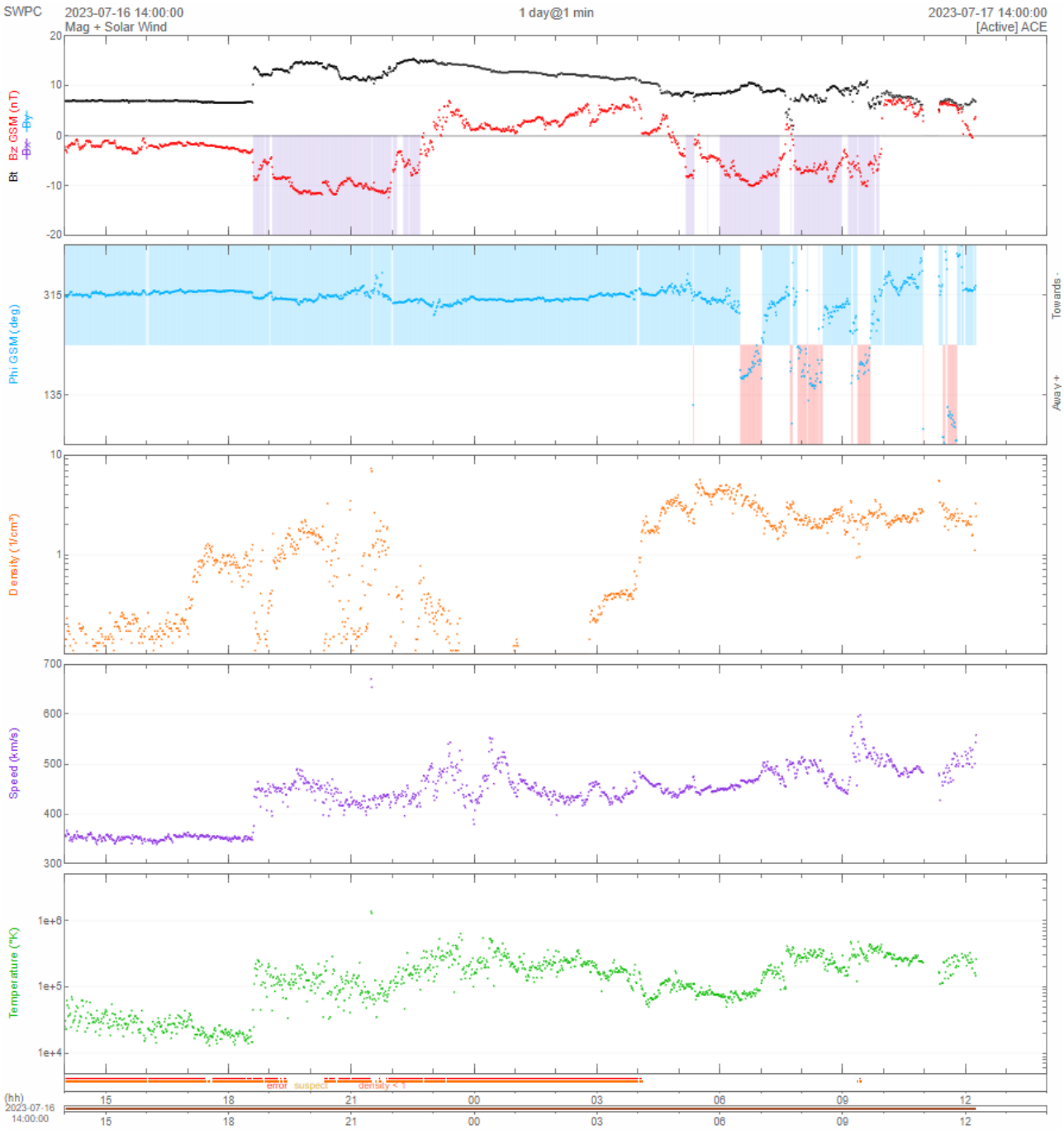
Figure 3: 24-hour plot of recent solar wind data at L1 with the CME arrival clearly visible.



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Radio Blackouts - X-Ray Flares:
Moderate activity is ongoing with the peak of M4.0 from AR3363 in the southwest quadrant, although AR3372 in the northwest also contributed a weaker M-class flare. Solar activity is expected to remain Moderate with a slight chance of X-class flares.

AR3363 is still assumed to be a complex region, although the position on the disc is starting to make a detailed analysis difficult. This region previously contained a delta spot, but this is no longer visible. AR3372 is large and complex with a small delta spot. AR3373 has slowed in development after previous growth but remains complex. The remaining regions are generally unremarkable.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	70	60	60
Very Active	R3 to R5 X Class	No	15	15	10	10

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Solar Radiation Storms - (High Energy Protons):
High energy (greater than 10MeV) proton flux rose to be above the S1 threshold (10 pfu) 16/0635-0905UTC, before gradually easing back towards background. This rise was likely due to a significant flare, associated with a fast CME that was observed on the far-side, just over the western horizon early on 16 July.

Flux has returned to background but further increases remain possible due to a further recent farsided eruption. There is also a risk from any flaring, mainly from sunspots on the western hemisphere disc, or further events over the western limb. Furthermore, the arrival of a CME on 17 July has the potential to sweep up interplanetary protons, increasing the flux for a short period during arrival. This will give a chance of further periods of S1 Minor Storm levels, mainly 17 July before the proton flux is expected to very gradually ease through the period.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	25	15	10	10
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) is forecast to be mainly background initially due to suppression from geomagnetic activity and distortion of the radiation belts from the stronger and denser solar wind. Waning effects through 19 and 20 July may then result in a sharp increase, with the magnitude of this dependent on the level of transfer of particles from the CME and any high speed stream to the radiation belts.

Electron fluence values are also well below the Active (1e8 integrated pfu), with relatively low confidence in the increase towards the threshold later in the period.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	20	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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